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This test operations procedure (TOP) presents test methods for use in evaluating the technical performance of rate of climb indicator systems relative to the appropriate Qualitative Materiel Requirements (QMR), Small Development Requirement (SDR), Technical Characteristics (TC), and Required Operational Capability (ROC).

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Item 20 Continued

The rate of climb instrument indicates only the rate at which an aircraft is gaining or losing altitude. The instrument is a valuable aid in flying under conditions of low visibility, such as fog, or in clouds, or at night. By means of this instrument predetermined angles of climb or decent can be accomplished. Conventional rate of climb indicators are considered to have an excessive lag before pressure stabilization, therefore, instantaneous rate of climb indicators have been developed, using the latest state-of-the-art techniques to eliminate this lag. Instantaneous rate of climb indicators simplify flight operations during ground control approach, altitude hold, and leveling off from ascent or descent. This TOP is limited to instantaneous rate of climb indicators only.

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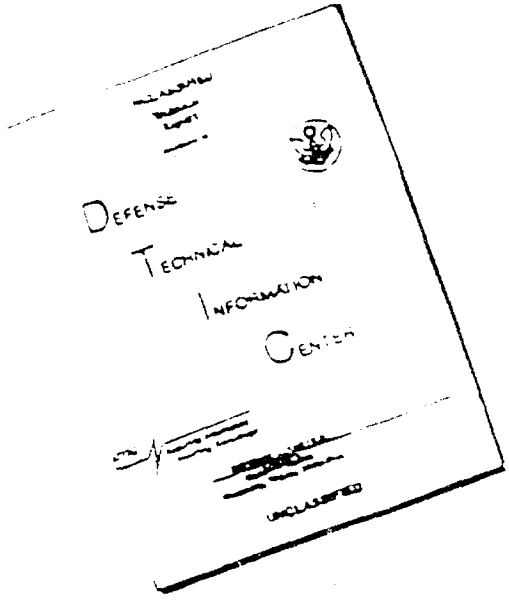

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US ARMY TEST AND EVALUATION COMMAND
TEST OPERATIONS PROCEDURE

DRSTE-RP-702-105 22 February 1983
Test Operations Procedure 6-2-235
AD No. A124828

RATE OF CLIMB INDICATORS (INSTANTANEOUS)

1.0 SCOPE. This test operations procedure (TOP) presents test methods for use in evaluating the technical performance of rate of climb indicator systems relative to appropriate Qualitative Materiel Requirements (QMR), Small Development Requirement (SDR), Technical Characteristics (TC), and Required Operational Capability (ROC). The rate of climb instrument indicates only the rate at which an aircraft is gaining or losing altitude. The instrument is a valuable aid in flying under conditions of low visibility, such as fog, or in clouds, or at night. By means of this instrument predetermined angles of climb or descent can be accomplished. Conventional rate of climb indicators are considered to have an excessive lag before pressure stabilization, therefore, instantaneous rate of climb indicators have been developed, using the latest state-of-the-art techniques to eliminate this lag. Instantaneous rate of climb indicators simplify flight operations during ground control approach, altitude hold, and leveling off from ascent or descent. This TOP is limited to instantaneous rate of climb indicators only.

2.0 FACILITIES AND INSTRUMENTATION. The test item shall be placed in operating condition as outlined in the equipment technical manual.

2.1 Facilities. An appropriate aircraft equipped with mercury and water manometers, vacuum, and pressure sources, camera with timer, mercury barometer, short bar magnet compass, stop watch, accelerometer, voltage recorder with timer, and a precision barometric altimeter. The facility shall have access to an altitude chamber.

2.2 Instrumentation and Equipment. The tolerances and technical characteristics of instrumentation and equipment used in these test procedures shall be adequate to conduct the following determinations:

a. Zero Setting - Determine if the adjustable zero setting range meets the applicable requirements.

*This TOP supersedes MTP 6-2-235, 1 January 1968.

b. Leakage - Determine if the leakage is within prescribed limits.

c. Scale Error - Determine if the test item scale errors are within acceptable limits.

d. Pointer Lag - Determine if the time required for the indicator-pointer to move from one position to another is within prescribed limits.

e. Position Error - Determine that the test item pointer position error is within prescribed limits.

f. Magnetic Effect - Determine the magnetic field generated by the test item.

g. Flight Test - Determine the effects of climbs, dives, and turns on the indicator reading.

3. PREPARATION FOR TEST

3.1 Facilities. Assure facilities are available.

3.2 Equipment. Assemble instrumentation listed in paragraph 2.1, and the test item to conform with the figures and instructions that follow.

3.3 Record the Following:

a. Record the nomenclature, serial numbers(s), manufacturer's name, and function of item under test.

b. Record the nomenclature, serial number, accuracy, tolerances, calibration requirements, and last day of calibration of the test instrumentation.

4.0 TEST CONTROLS

a. Assure that test personnel are familiar with the required technical and operational characteristics of the item under test, such as stipulated in QMR, SDR, and TC.

b. Assure that instructional material issued with the test item by the manufacturer, contractor, or Government shall be readily available for reference by test personnel. Test personnel shall be familiar with the contents of such documents prior to start of tests.

c. Assure that the test item is thoroughly inspected for obvious physical and electrical defects such as cracked or broken parts, loose connections, bare or broken wires, loose assemblies, bent fragile parts, and corroded plugs and jacks. All defects shall be noted and corrected before proceeding with the test.

5.0 PERFORMANCE TESTS. Conduct all tests under guidance of procedures contained herein. Make modifications of these procedures as required by technical design of the test item and availability of test equipment, but only to the extent that such modified procedures will not affect the validity of the test results.

5.1 Zero Setting. Zero setting of the equipment shall be determined as follows:

a. Determine the zero adjust range from the test item specifications.

b. Rotate the zero adjust screw to the up and down limits.

c. Observe and record the indicated limits.

5.2 Leakage. Leakage shall be determined as follows:

a. Connect the static connection of the test item to a mercury manometer and a vacuum and pressure source with heavy duty rubber tubes. (See figure 1.)

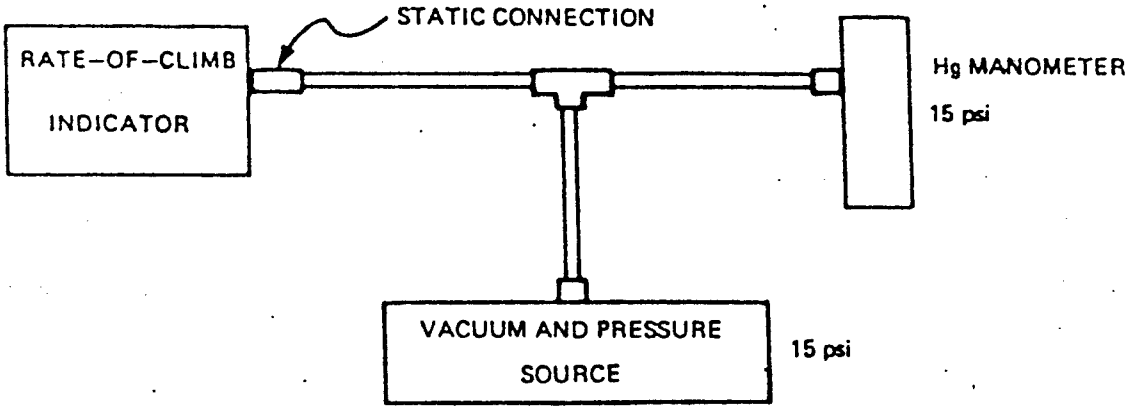

Figure 1. Equipment Setup Leakage Determination.

b. Pull a vacuum to a predetermined amount using the vacuum source and ensure that the vacuum is maintained at the prescribed amount.

c. Observe and record the indication on the test item and the indicated reading on the manometer.

d. Apply a predetermined pressure using the pressure source. Read the pressure indication on the manmometer and ensure that the reading is maintained at the prescribed amount. If the reading is not constant, the cause of leakage shall be determined.

e. Observe and record the indication on the test item.

5.3 Scale Error. The scale error in the rate-of-climb or descent-versus-time indicator shall be determined as follows:

a. Set test item pointer at zero.

b. Place test item in an altitude chamber.

c. Connect a mercury barometer to the altitude chamber.

d. Reduce the chamber pressure at such a rate that the test item pointer indicates a given rate of ascent (e.g., 500 fpm).

e. Determine, with a stop watch, while the pointer indicates the given rate of ascent, the time required for the mercury barometer to change from a pressure point corresponding to 1000 feet altitude to one corresponding to 1500 feet.

f. Increase the chamber pressure at such a rate that the test item pointer indicates a given rate of descent (e.g., 500 fpm).

g. Repeat step e for a pressure change corresponding to a descent from an altitude of 1500 feet to one of 1000 feet.

h. Continue with this procedure for the test rates and altitudes shown in table I. Indicators with maximum indication of 3000 fpm shall not be subjected to test rates exceeding that maximum.

i. Observe and record, for each altitude interval, the rate of ascent or descent versus time as determined by stop watch and as shown on the indicator.

j. Compare readings on stop watch and mercury barometer with reading shown on test item.

TABLE I. TEST RATES AND ALTITUDES

Standard Altitude Interval (Feet)	Test Rate (fpm)
1000 to 1500 1500 to 1000	500
1000 to 2000 2000 to 1000 2000 to 4000 4000 to 2000	1000
2000 to 4000 4000 to 2000	1500
2000 to 4000 4000 to 2000	2000
2000 to 4000 4000 to 2000	3000
2000 to 4000 4000 to 2000	4000
2000 to 4000 4000 to 2000	5000
15,000 to 17,000 17,000 to 15,000	1000
15,000 to 17,000 17,000 to 15,000	2000
15,000 to 17,000 17,000 to 15,000	3000
15,000 to 17,000 17,000 to 15,000	4000
28,000 to 30,000 30,000 to 28,000	1000
28,000 to 30,000 30,000 to 28,000	2000
28,000 to 30,000 30,000 to 28,000	3000
28,000 to 30,000 30,000 to 28,000	4000

5.4 Pointer Lag. Pointer lag shall be determined as follows:

a. Connect the test item static connection to a water manometer and a vacuum, and pressure source. (See fig. 2.)

b. Select two points of pressure and two of vacuum to use as marks for taking time readings.

c. Apply a pressure so that it causes an indication on the manometer above the high pressure point selected as the time marker.

d. Release the pressure immediately.

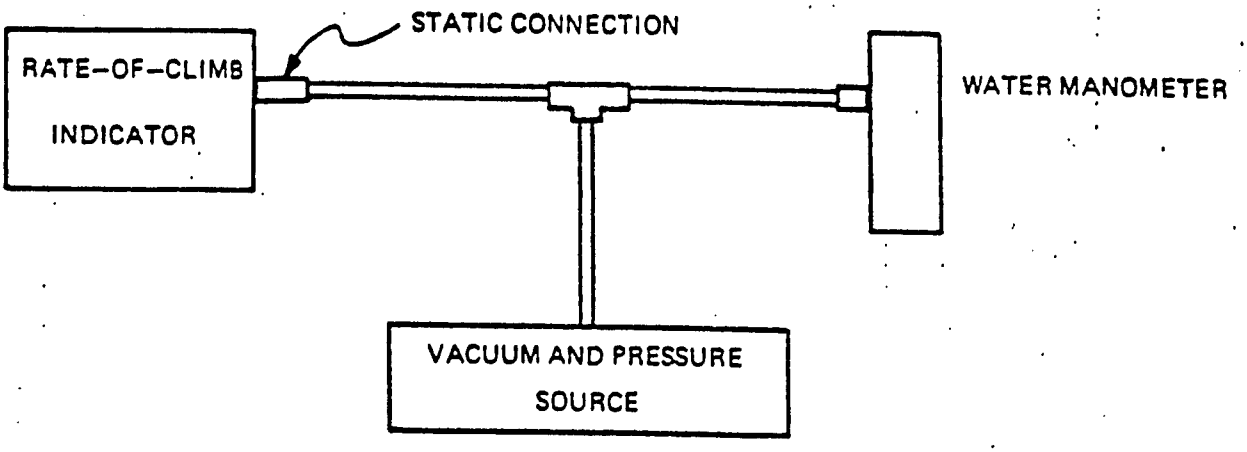

Figure 2. Equipment Setup Pointer Lag Time Determination.

e. Start a stop watch the instant the pointer passes the high pressure mark and record.

f. Stop the stop watch the instant the pointer passes the low pressure mark and record.

g. Repeat step c using a vaccum instead of pressure.

h. Release the vacuum immediately.

i. Repeat steps e and f.

NOTE: For greater resolution accuracy, the operation can be photographed at a rate of approximately 10 frames per second.

5.5 Position Error. Position error shall be determined as follows:

a. Place the test item in a normal operating position.

b. Apply a predetermined amount of vacuum using the 5.2 setup.

c. Observe and record the test item pointer indication.

d. Rotate test item 90 degrees up from normal operating position.

e. Observe and record the test item pointer indication.

f. Rotate the item 90 degrees down from normal operating position.

g. Observe and record the test item pointer indication.

h. Rotate the item 90 degrees to the right from normal operating position.

i. Observe the test item pointer indication.

j. Rotate the item 90 degrees to the left from normal operating position.

k. Observe and record the test item pointer indication.

l. Repeat step b applying a predetermined pressure.

m. Repeat steps c through k.

NOTE: For steps d, f, h, and j, see figure 3.

5.6 Magnetic Effect. The magnetic effect generated by the test item shall be determined as follows:

a. Place the test item a short, predetermined distance from the center of a short, bar-magnet compass.

b. Hold the test item at various positions east or west of magnetic north and with its nearest part a predetermined distance from the center of a short bar-magnet compass.

c. Observe and record the compass deflection.

5.7 Flight Tests. The flight test of the test item shall be determined as follows:

a. Mount the test item on a panel on board the test aircraft.

b. Mount a precision barometric altimeter on the panel.

c. Mount an accelerometer on the panel.

d. Set all instruments to zero.

e. Connect the static port of required instruments to a common static source.

f. Connect the voltage recorder with timing device to the voltage output of the precision altimeter.

g. Mount the test panel facing a 16 mm camera suitably mounted to permit complete coverage of the test panel.

h. Fly the test aircraft up to approximately 4000 feet above terrain.

i. Turn on camera and voltage recorder.

j. A series of six climb and dives shall be accomplished at altitudes between 1000 feet and 4000 feet above terrain at a test rate of 1000 fpm. Pilot will determine test climb and dive rates with existing cockpit instrumentation. Actual rates will be as recorded from test instrumentation using the precision barometric altimeter as a base line.

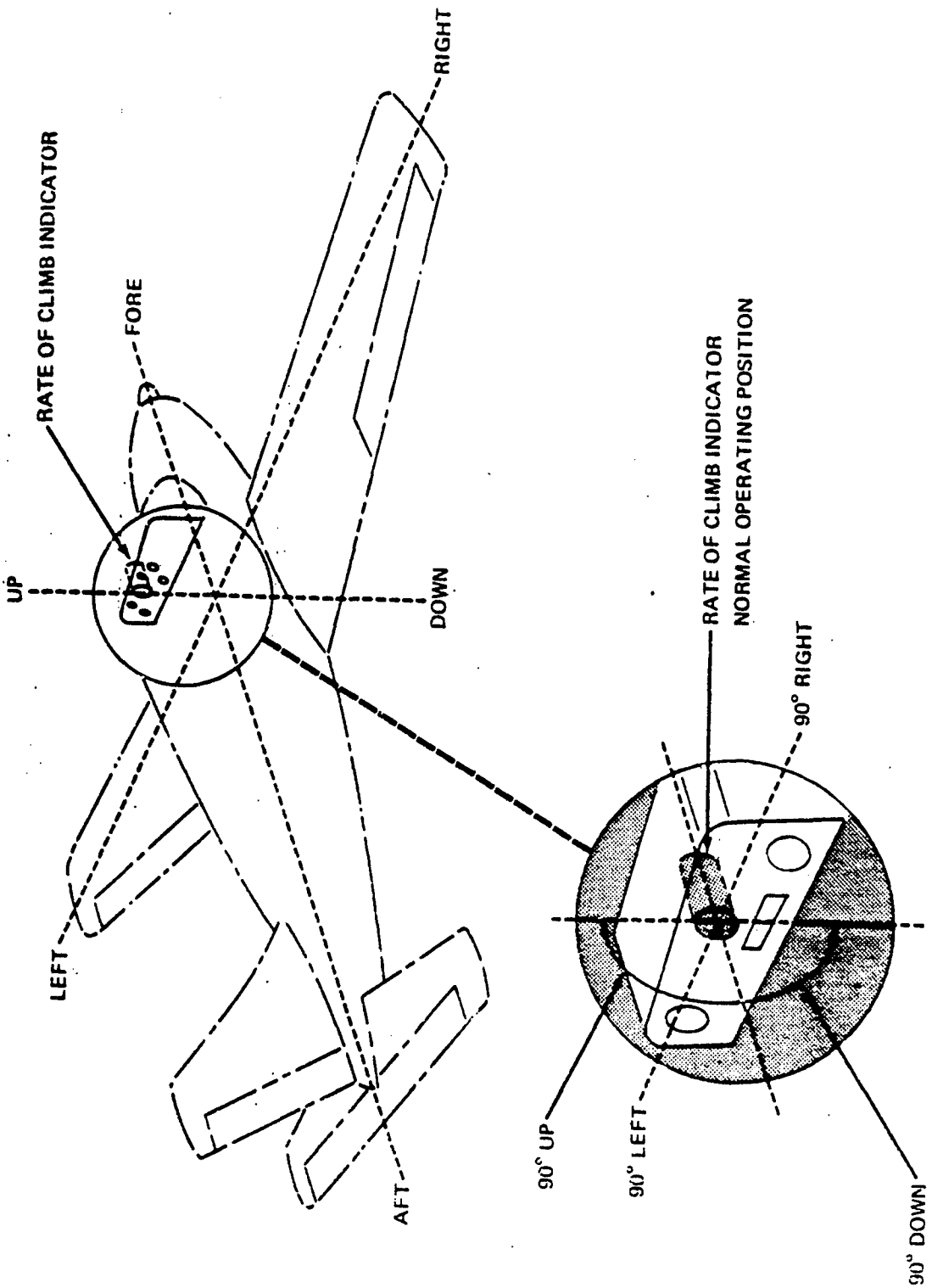

Figure 3. Rate of climb indicator normal operating position.

k. The recovery maneuvers shall be executed to produce vertical accelerations of approximately 32 ft/sec^2 (1G) in climb and dive respectively in accordance with known aircraft flight performance characteristics. Actual acceleration will be determined from test instrumentation.

l. Repeat the series of climbs and dives while executing standard left and right turns. Pilot will determine test climb and dive rates with existing cockpit instrumentation. Actual rates will be recorded from test instrumentation using the precision barometric altimeter as a base line.

m. A series of climbs and dives shall be accomplished at altitudes between 1000 and 1500 feet above terrain at a test rate or 500 fpm.

n. Repeat step 1 while executing standard left and right turns.

o. Observe the difference between the barometric altimeter readings and the test item indication both at 1000 and 500 fpm and when executing left and right turns for each test rate.

p. Observe and record the G rate obtained for 1000 fpm test rate.

q. Observe and record altimeter reading.

r. Observe and record rate of climb indicator reading.

NOTE: The above information shall be recorded as indicated in table II.

6.0 TEST DATA. Test data shall consist of the progressive documentation of test results and shall be recorded as follows:

6.1 Zero Setting Tests

a. Record the zero adjust range from test item specification.

b. Record maximum zero adjust scale readings.

6.2 Leakage Tests

a. Record the vacuum reading on the manometer.

b. Record the test item scale readings.

c. Record the pressure reading on the manometer.

d. Record the test item scale reading.

6.3 Scale Error Tests

a. Record the rate of ascent and descent in tabulated form.

b. Record each altitude interval of ascent or descent.

TABLE II. TABULATION DATA FORM

Aircraft Type _____ SN _____

Altimeter Type _____ SN _____

Accelerometer Type _____ SN _____

	Dive		Dive with 90° Left Turn	
Altitude (ft)	4000 - 1000	1500 - 1000	4000 - 1000	1500 - 1000
Rate (fpm) nom/actual	1000	500	1000	500
G Rate ft/sec^2 nom/actual	32	NA	32	NA
Altimeter Reading	_____	_____	_____	_____
Rate of Dive Indicator Reading	_____	_____	_____	_____
	Climb		**Climb with 90° Right Turn**	
Altitude (ft)	1000 - 4000	1000 - 1500	1000 - 4000	1000 - 1500
Rate (fpm) nom/actual	1000	500	1000	500
G Rate ft/sec^2 nom/actual	32	NA	32	NA
Altimeter Reading	_____	_____	_____	_____
Rate of Dive Indicator Reading	_____	_____	_____	_____
	etc.		etc.	

c. Record the time interval corresponding to each altitude interval.

6.4 Pointer Lag Tests

a. Record the pressure and vacuum readings.

b. Record the rate of ascent and descent readings to be used as time markings.

c. Record time between markings for both ascent and descent.

6.5 Position Error Tests

a. Record predetermined pressure and vacuum in tabulated form.

b. Record test item pointer indication at normal operating position.

c. Record test item pointer indication at other prescribed positions.

d. Record maximum deviation at each position.

6.6 Magnetic Effect Tests

a. Record distance between test item and center of short bar magnet compass.

b. Record largest compass deflection.

6.7 Flight Tests

a. Record aircraft type, altimeter and accelerometer type in tabulated form.

b. Record altitude of climbs and dives, turns executed, test item indications, G rate for the 1000 fpm test rate.

7.0 DATA REDUCTION AND PRESENTATION

7.1 Zero Setting Tests. Present the comparison of the actual readings with the test item requirements and specification.

7.2 Leakage Tests

a. Present comparison of the results of leakage tests with applicable requirements and specifications.

b. Present comparison of manometer readings with theoretical readings for given indication on the test item.

7.3 Scale Error Tests

a. Present comparison of the results of the scale error tests with applicable requirements and specifications.

b. Present comparison of the rate of climb or descent versus time for each altitude interval.

c. Plot readings on indicator at various test positions versus the timed readings.

7.4 Pointer Lag Tests

a. Present comparison of the results of pointer lag tests with applicable requirements and specification.

b. If the operation is photographed, present comparison of time intervals indicated on the film with those obtained by the stop watch method.

7.5 Position Error Tests

a. Present comparison of the results of position error tests with applicable requirements and specifications.

b. Present comparison of maximum deviation readings with prescribed limits.

7.6 Magnetic Effect Tests

a. Present, in tabular form, the compass deflection for various test item positions.

b. Present comparison of the compass deflection with applicable requirements and specifications.

7.7 Flight Tests

a. Present results of flight test in tabular form as shown in table II.

b. Present comparison of results of flight tests with applicable requirements and specifications.

c. Present comparison of results obtained from the altimeter voltage recorder and time versus camera and timer.

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